The Footprint of NOAA CO-OPS Products and Data in the US User Community, 2005

Report to NOAA CO-OPS
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Hauke Kite-Powell
hauke@whoi.edu

Summary

This document describes the product suite and user base for NOAA's Center for Oceanographic Real-Time Products (CO-OPS) as they exist at present (2005). It estimates in quantitative terms the distinct segments of the user base for CO-OPS products and services, and the annual volume of CO-OPS data and information that reaches each segment of the user community, both directly and indirectly through other government agencies and through private sector value-added information resellers.

CO-OPS data may be used either directly (by a user accessing CO-OPS information online or via a data request to CO-OPS) or indirectly (by using a weather forecast or tide prediction, published by an agency or organization other than CO-OPS, that incorporates CO-OPS data). Table 1 summarizes the estimates generated in this report for the annual utilizations, or instances of CO-OPS data reaching end users, per year. The table distinguishes between near-real time (RT) data (often associated with PORTS), predictions (such as those published in the Tide Tables), and historical records. Indirect utilization of CO-OPS data is indicated by shaded fields in Table 1.

		utilization (uses per year)		
	user base scale	**near RT / PORTS**	**Predictions**	**historical / archival**
commercial shipping	[10,000] vessels	[100,000] transits	[500,000] transits	
commercial fishing	[30,000] vessels		[300,000] transits	
Recreational boating/fishing	[20 million] boats [20 million] fishers	[5 million] trips	[500 million] trips	
USCG (SAR) NOAA Hazmat		[30,000] SAR cases [1,000] hazardous material spills		
US Navy, US Coast Guard	[500] vessels	[20,000] transits		
science, environmental management, infrastructure projects	[10,000] marine GIS users	[1,000] ?	[1,000] ?	[1,000] ?
public weather forecasts	[10 million] households	[4 billion] household-days		
storm surge predictions	[10 million] households	[200 million] household-days		

Table 1: Scale of user base and frequency of CO-OPS products reaching end users, 2004. [Brackets] indicate that numbers are approximate, and should in most cases be treated as order of magnitude estimates. Shaded boxes represent indirect utilization of CO-OPS data.

User base. The largest component of the user base for CO-OPS products is the recreational boating community and (if indirect use via weather forecasts is included) the general public in coastal communities, with tens of millions of potential users. By contrast, the number of commercial cargo and passenger ships in US waters is three

orders of magnitude smaller (on the order of 10,000), and the number of military ships is two orders of magnitude smaller yet (in the hundreds).

Overall utilization numbers. The commercial shipping industry, the US military, and government agencies responsible for search & rescue (SAR), hazardous material spill response and planning, and environmental management, account for between 500,000 and 1 million instances of direct use of CO-OPS data each year. Recreational users may account for another 5 million instances of direct use per year, although the evidence for this is less certain. Instances of indirect use of CO-OPS data are estimated on the order of 1 billion/year for marine applications (tide predictions and storm surge forecasts), or 5 billion/year if general weather forecasts incorporating CO-OPS data are included.

Principal conclusions:

- The non-traditional users of CO-OPS products – including recreational boaters and coastal residents, as opposed to maritime transportation and the US military – now account for a major, and rapidly growing, fraction of the total CO-OPS user base.
- The PORTS® model of near-real time data, combined with nowcast and forecast model output, and graphic user interfaces, is consistent with the overall trends toward obtaining weather and marine conditions information in digital form via the internet, and may be the best way for CO-OPS to reach the largest segments of its user base.
- CO-OPS is well-positioned to play a role in the emerging system of regional coastal ocean observing systems envisioned by the IOOS strategy of Ocean.US. PORTS® systems and the CO-OPS network of water level stations may serve as local models or prototypes for regional systems. CO-OPS' essential function in quality control, archiving, integration, and dissemination of data from water level stations is precisely the envisioned federal role in coordinating future regional ocean observing systems.
- Priority areas for economic analysis suggested by this report include:
    - PORTS® installations (as done recently for Tampa Bay)
    - utilization of tide predictions by recreational users (large user base)
    - utilization of CO-OPS data in weather and storm surge prediction (large user base)
    - value of improved surface current now- and forecasts to Search & Rescue (SAR) and spill response activities (large unit value)

List of Acronyms

CO-OPS	Center for Operational Oceanographic Products and Services
DoD	Department of Defense
EEZ	Exclusive Economic Zone
GIS	Geographic Information System
NGA	National Geospatial-Intelligence Agency
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OCS	Office of Coast Survey
PORTS®	Physical Oceanographic Real-Time System
SAR	Search and Rescue

Introduction

The Center for Operational Oceanographic Products and Services (CO-OPS) resides within the National Ocean Service of the National Oceanographic and Atmospheric Administration (NOAA). CO-OPS collects and distributes oceanographic observations and predictions to support maritime commerce, provides water level and coastal current oceanographic products, measures and predicts tides throughout the nation, and is responsible for disseminating this information to the public.

CO-OPS manages the National Water Level Observation Network (NWLON), which provides basic tidal information to provide vertical control (tidal datums that determine U.S. coastal marine boundaries) and to support the creation of nautical charts. The tidal information is also used for storm tide and tsunami warnings, hazardous material response, habitat restoration, coastal zone management, and other non-navigational applications. CO-OPS also manages a national network of Physical Oceanographic Real-Time Systems (PORTS®) that to date have been installed in 13 major US harbors. The PORTS® network provides real-time information such as water levels, currents, air gap (the clearance between the water surface and the bottom of a bridge), meteorological and other oceanographic data to mariners to help them avoid groundings and collisions.

In addition, CO-OPS establishes standards for the collection and processing of water level and current data, conducts research into new or improved oceanographic observing systems, designs software for improved processing of oceanographic data, and performs data analysis and quality control on information obtained from the NWLON and PORTS systems.

The activities and products of NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) contribute to a wide range of economic benefits to industrial and recreational activities in the United States. A detailed accounting of these benefits is difficult because they arise from complex behaviors and decisions made by many different people in very different user sectors. To provide a sound basis for prioritizing and carrying out detailed benefit estimates for CO-OPS activities in light of this difficulty, we describe in this document the "footprint" of CO-OPS activities in the end-user communities today, and to describe in qualitative terms how data and products from CO-OPS activities lead to economic value generation.

This document describes the CO-OPS product suite and user base as they exist at present (2005). It describes in quantitative terms the distinct segments of the user base for CO-OPS products and services, and the annual volume of CO-OPS data and information that reaches each segment of the user community, both directly and indirectly through other government agencies and through private sector value-added information resellers.

CO-OPS products and services that are directly available to end users include:

- PORTS® products
- Tide predictions
- Tidal current predictions

- Water level observations (Tides and Great Lakes Online)
- Tidal datums and other derived tide data products (tidal zoning)
- Long term sea level trends information
- Technology transfer, training, consultation services, and certifications for litigation

Prominent examples of private sector products derived from CO-OPS data include the various tide predictions published in nautical and fishing publications, daily newspapers, wireless services, and other media.

User community segments include:

- Commercial maritime transportation (shipping)
- Commercial fishing
- Military and other Federal agencies such as Navy, Coast Guard, and Army Corps of Engineers
- Other parts of NOAA such as the National Weather Service and NOAA Research
- Recreational boating, fishing, and beach/swimming activities (private individuals)
- Mapping and charting (NOAA Office of Coast Survey)
- Surveying and coastal engineering
- Coastal zone managers (habitat restoration, port and waterfront development planning, shoreline protection, marine boundaries, etc.)
- Emergency planners (storm surge forecasting)
- Emergency response (search and rescue, hazardous material spill response)
- Research (circulation modeling, long term sea level trends, etc.) and education, primary schools to universities
- Litigation/lawyers

Web pages:
PORTS® http://140.90.121.76/d_ports.html
Great Lakes Online http://glakesonline.nos.noaa.gov/
Tides Online http://tidesonline.nos.noaa.gov/
Sea Levels Online http://140.90.121.76/sltrends/sltrends.shtml

Products Based on CO-OPS Data

This section provides background on products derived from CO-OPS data, both those provided directly by CO-OPS and those produced by other public or private-sector operations.

CO-OPS Products

Water Level Observations

NOAA CO-OPS today maintains about 187 permanent water level stations around the country, plus some 50 to 60 short term stations that are moved around to support specific hydrographic survey efforts. (Some 200 permanent stations were maintained in 1980.)

In 1980, water level stations used electromechanical float sensors to measure water level, and recorded the data on paper tape that was collected once a month. In the late 1980s, these sensors were replaced with more accurate acoustic devices that record measurements every six minutes and relay data to NOAA via satellite every three hours. More recently, the upload interval has been shortened to one hour, and the objective is to shorten it further; CO-OPS is presently in the process of upgrading its water level stations to transmit data every six minutes and will have completed this by the end of FY2007.

About 100 of these permanent network stations have been equipped with meteorological sensors since the mid-1990s, and now provide wind speed, wind direction, air temperature, and air pressure at six-minute intervals as well.

CO-OPS water level observations are made available to users via the internet through a series of CO-OPS web pages. The main water level observations interface is at http://140.90.121.76/data_res.html. Water level observations and tide predictions (see below) are also available via Tides Online (http://tidesonline.nos.noaa.gov/) and Great Lakes Online (http://glakesonline.nos.noaa.gov/). Long-term sea level trends data are available via Sea Levels Online (http://140.90.121.76/sltrends/sltrends.shtml). Data from certain CO-OPS Physical Oceanographic Real-Time System (PORTS) sensors (see below) are available at http://140.90.121.76/PORTS_Archives/PORTS_DataHist.html.

All of the data sources above provide historical water level data that has been quality-controlled by CO-OPS personnel. The Continuous Operational Real-time Monitoring System (CORMS) was developed in the mid-1990s as a spinoff from PORTS® (see below), with the goal of making water level and related observations available to users in near-real time. For liability reasons, CO-OPS cannot make data available in near-real time without verifying its accuracy; and CORMS development focuses on automating this quality control function.

PORTS® Information Products

NOAA began to provide real-time water level and current data for local areas in selected ports around the country in the late 1980s, as a resource for commercial shipping and for recreational boaters/fishers. The Physical Oceanographic Real-Time Systems (PORTS®) are near-shore ocean observing systems now operating in 13 locations around the United States (http://co-ops.nos.noaa.gov/d_ports.html). PORTS installations provide near-real time information and, in some cases, forecasts about water levels and currents at specific points in a coastal water body. In some instances, they also provide information on wind speed and direction, air gaps for bridges, and on water temperature. In addition, co-located sensors (i.e., possibly operated by other parties and not part of the official NOAA PORTS® installation) may provide information on wave height, visibility, and other parameters, as well as digital still or video images of portions of the waterbody. Information is made available to users via telephone and/or internet connections.

The first PORTS® was installed in Tampa Bay following the 1980 Sunshine Skyway Bridge ramming. The following PORTS installations were operating as of 2005:

- San Francisco Bay
- Tampa Bay
- Soo Locks
- New York/New Jersey Harbor
- Chesapeake Bay
- Los Angeles/Long Beach
- Port of Anchorage
- Houston/Galveston
- Narragansett Bay
- Delaware River and Bay
- Lower Columbia River
- Port of Anchorage
- New Haven

Until recently, tidal current observations at CO-OPS took place primarily in the context of PORTS® installations and special project surveys, which typically deployed 15 to 30 short term stations per year. Tide current charts were withdrawn from production in 1991. However, CO-OPS recently received an increase in funding that will support certain tide current observations at 70 locations annually to update tidal current predictions. Current tables published in the Tide Tables books (see below) for the Atlantic and Pacific coasts of the United States are based on historical data, which may not be as useful as those generated by a modern survey.

Water Level and Tidal Current Predictions

Tide tables provide forecasts of high and low water times and levels. They are a mandated (by Coast Guard regulation) carriage item on commercial ships in US waters.

NOAA CO-OPS provides water level (high and low tide) predictions for about 3,000 locations and tidal current predictions (time of slack water; maximum flood and ebb current speed and direction) for about 2,700 locations around the United States. Harmonic constituents are known for about 700 of these stations, allowing water level predictions to be generated for shorter (typically 6 minute) intervals. The long-term predictions published in the tide tables are based on lunar cycles and do not incorporate meteorological forcing of water levels and currents. They are available via the internet (http://140.90.121.76/tide_pred.html) and in print.

Full daily predictions are published for a limited number of "reference stations." The remaining stations are referred to as "subordinate stations." Tidal predictions for the subordinate stations can be obtained by applying specific differences to the times and heights of tides of the specified reference stations. CO-OPS is working on a system to automate these calculations. Tide stations and tidal current stations are separate entities: tide stations are normally located along the shoreline, at a pier, jetty, breakwater or other physical structure; tidal current stations are typically located away from the shoreline, often in or near navigational channels.

Operational nowcast and forecast models for water levels and currents are operated by CO-OPS for the Port of New York/New Jersey and for Chesapeake Bay, Houston/ Galveston, the St. Johns River in Florida, and Lakes Erie and Michigan. These models incorporate meteorological forcing (wind, precipitation/river flow, etc.) and thus provide more accurate short term (up to 30 hour) forecasts than the standard predictions. Similar models are operated by parties other than NOAA in Tampa and San Francisco Bay, among other locations, usually making use of observations from PORTS® installations.

CO-OPS tidal water level predictions, and similar data from 22 other countries, are published annually in book form, in a set of six volumes produced by three commercial publishers. While most of the US predictions are available via the CO-OPS web pages, the international data are not available through that channel. On the order of 10,000 copies are printed of each volume. The manuscripts are also published separately for military use by the US National Geospatial Intelligence Agency (NGA).

Historical Time Series of Water Level Data

Complete time series for about 50 water level stations are "verified" and available to users directly via the internet. Most of the other data, including most data from prior to 1995, are not available via the internet but can be released on special requests; they may not be verified and may not be in electronic form.

Other archival information available from CO-OPS, generally not via the web pages, includes:

- Tidal zoning – tide delays and height differentials interpolated between stations
- Harmonic constitutents for tide stations
- Various tide prediction algorithms and programs

- Historical data (prior to 1993) on water temperature and density

Long Term Sea Level Trends and Tidal Datums

CO-OPS makes available analyses of the rate of mean sea level rise or fall for 117 long term water level stations (http://140.90.121.76/sltrends/sltrends.shtml). Monthly mean sea level data are used to determine the linear trend, the average seasonal cycle, and the interannual variations. The linear trend at a coastal location is primarily a combination of the global sea level rise and any local vertical land movement. The seasonal cycle and interannual variations are caused by fluctuations in coastal ocean temperatures, salinities, winds, atmospheric pressures, and currents. The interannual variations for many Pacific stations are closely related to the El Niño/Southern Oscillation. CO-OPS also provides map images to show the regional extent of anomalously high or low water levels.

Derivative/Value-added Products

Both federal agencies (such as the National Weather Service) and private sector purveyors of marine conditions and weather forecasts make use of CO-OPS data. This use of CO-OPS data produces an indirect channel for the utilization of CO-OPS information by end-users.

Weather and Storm Surge Forecasts

Observations of atmospheric conditions, such as winds, are an input to general weather forecast models; and water level observations and forecasts are an input to storm surge predictions. NOAA's National Weather Service and private sector weather forecast services develop general weather forecasts, coastal marine weather forecasts, and predictions of storm surge for extreme weather events, using CO-OPS data in combination with other observations.

These forecasts are used by businesses and individuals on a daily basis, and allow users to make decisions that improve a wide range of economic outcomes. The value of improved coastal marine forecasts is reflected in the improved recreational boating experience of local boaters, as discussed above. The improved general weather forecasts benefit all users of weather forecasts in the area. Storm surges are associated with large storm events, such as hurricanes, and can cause extensive damage. Much of this damage cannot be avoided by an improved forecast, but some improvements in response activities (securing boats and structures, evacuating areas) may be possible or less costly with a more accurate and timely forecast.

Tide and Current Predictions

Like all US government publications, CO-OPS tide and water level predictions are not subject to copyright. Numerous private-sector companies copy or convert CO-OPS tide tables to create value-added products for targeted markets. Examples include publications such local or regional waterway guides and chart books, fishing guides, and daily tide predictions published or broadcast by print, radio, and television media.

Some private operations develop their own tide predictions based on observations and harmonic constituent information obtained or derived from CO-OPS data, develop various graphical representations, and make these predictions available at a price to end users (typically media outlets, but sometimes individual users). For example, Ekkosoft (http://www.ekkosoft.com/SWTpage.html) makes available NOAA tide data in graphic and text formats to subscribers via their mobile phones.

User Base

Commercial Maritime Navigation

The world's commercial fleet consists of about 40,000 vessels above 1,000 gross tons. These vessels have been steadily growing in size, both in draft (depth) and in elevation, challenging constraints imposed by dredged channels and overhead structures such as bridges. These vessels are subject to the International Maritime Organization's Safety of Life at Sea Convention (SOLAS) and as such are legally required to carry and use official tide tables. On the order of 10,000 commercial vessels (including non-SOLAS vessels such as tug/barges) operate in US waters and are required to carry tide tables. These vessels collectively make on the order of 250,000 port calls, or about 500,000 port transits, in US waters per year.

The original international carriage requirement for tide tables (and nautical charts, etc.) was codified in the International Convention for the Safety of Life at Sea of 1974 (SOLAS), Chapter V, Regulation 20: "All ships shall carry adequate and up-to-date charts, sailing directions, lists of lights, notices to mariners, tide tables, and all nautical publications necessary for the intended voyage."

The SOLAS carriage requirements were implemented for US waters by the Coast Guard under Navigation Safety Regulations adopted in 1977 and amended in 1983 (33 CFR 164). The US Coast Guard recognizes as "adequate" for this purpose the tide tables now published by private publishers using predictions generated by CO-OPS and reproduced to CO-OPS specifications.

According to Regulation 9 of the revised Chapter V of SOLAS:

> Contracting Governments undertake to arrange for the collection and compilation of hydrographic data and the publication, dissemination and keeping up to date of all nautical information necessary for safe navigation.
>
> In particular, Contracting Governments undertake to co-operate in carrying out, as far as possible, the following nautical and hydrographic services, in the manner most suitable to the purpose of aiding navigation: .1 to ensure that hydrographic surveying is carried out, as far as possible, adequate to the requirements of safe navigation; .2 to prepare and issue nautical charts, sailing directions, lists of lights, **tide tables** and other nautical publications, where applicable, satisfying the needs of safe navigation; .3 to promulgate notices to mariners in order that nautical charts and publications are kept, as far as possible, up to date; and .4 to provide data management arrangements to support these services. [Emphasis added.]

Commercial vessels calling on US ports thus are obligated by law to carry printed tide tables based on CO-OPS predictions. In locations where near-real time observations and dynamic predictions are available (e.g. PORTS installations), many commercial vessels also make use of this information to improve the safety and efficiency of their transits.

Recreational Boating and Fishing

About 20 million recreational boats operate in the United States, and 75 million Americans participate in recreational boating activities. Most of the boats are small (canoes, rowboats, "johnboats"), and most of these operate on smaller inland waters where water levels and tidal currents are of little or no significance. Just over half of all recreational vessels are registered with state authorities. An estimated 1 million boats – motor and sailboats around 20 feet in length or greater – are routinely operated in marine or Great Lakes environments, where tide level and current considerations may be relevant. These account for over 250 million person-days/year of marine recreational boating.

More than 20 million individual participate in marine recreational fishing in the United States, and collectively spend more than 280 million person-days/year on this activity. Recreational fishers in many cases use information about tides to guide the timing of their fishing activities because the likelihood of catching fish in many cases depends on current and/or water level.[1]

U.S. Navy

US military vessels carry tide tables based on CO-OPS predictions and published by the National Geospatial-Intelligence Agency (NGA). The Navy fleet has decreased in size since 1987 to about 300 ships today, and is expected to shrink further, perhaps to around 200 ships by 2020. The US Coast Guard operates about 220 vessels.

GIS and Modeling Work

With the advent of digital geographic information systems (GIS) in the 1990s, land use planners, resource managers, and others have made increasing use of digital map and chart data as "base layers" to support GIS analyses. Today, an estimated 10,000 GIS users in the United States make use of nautical and marine data layers for GIS applications. Users include:

- researchers (models: circulation, fish habitat)
- engineering companies
- marine resource managers (fisheries, marine minerals, etc.)
- coastal zone managers

It is not known how many of these use CO-OPS data in their work.

[1] National Survey on Recreation and the Environment: http://marineeconomics.noaa.gov/NSRE/welcome.html

National Weather Service

The National Weather Service receives a direct feed of all water level data from CO-OPS, as well as meteorological data from water level network stations, and distributes CO-OPS data via AWIPS, the NWS data distribution system. NWS produces storm surge predictions, coastal flood warnings, and coastal marine and terrestrial weather forecasts in part on the basis of CO-OPS data. NWS also performs quality control on the CO-OPS met data and helps CO-OPS identify problems with its met sensors.

NWS largely receives CO-OPS data via the internet, except for some weather service offices in the vicinity of Galveston, Texas, which utilize water level predictions for certain stations that are not deemed accurate enough by CO-OPS to be made available to the general public.

US Coast Guard – Search and Rescue

The US Coast Guard conducts some 30,000 search and rescue (SAR) missions and saves some 5,000 to 6,000 lives each year in US waters. Significantly, between 100 and 200 lives are lost in marine accidents each year after the Coast Guard has been notified that they are at risk.[2] Perhaps the most critical factor determining the success of SAR missions is the time it takes the Coast Guard to get to the person at risk. The SAR success rate is only about 4% when this time exceeds 2 hours.

Understanding the currents and winds in the vicinity of the SAR target is critical to locating and reaching the person quickly. Improved nowcasts of surface currents, therefore, can be expected to improve SAR effectiveness and lead to significant benefits. For example, a 1% improvement in SAR effectiveness (from 90% to 91% lives-at-risk saved) in the US Gulf of Maine alone would result in an additional 6 lives saved per year, with an economic value of some $24 million. (We assume here a conservative value for a human life of $4 million.[3]) Additional benefits can be realized from reduced SAR costs and reduced risk to SAR personnel.

Other Government Organizations

CO-OPS has cooperative agreements with the US Army Corps of Engineers to provide water level and current data in support of specific USACE waterways projects. NOAA Hazmat receives all CO-OPS annual predictions for spill response planning and preparation and modeling. CO-OPS also has arrangements with other regional and state government entities, such as regional ocean observing systems, for collaborative observing activities and data exchange.

Private Weather Forecasters

Private weather forecasting services – many affiliated with television stations or newspapers – obtain CO-OPS data and predictions and incorporate them into their products. CO-OPS "competes" in this area increasingly with private providers of tide

[2] http://www.uscg.mil/hq/g-o/g-opr/sar.htm
[3] Viscusi, W.K. 1993. The value of risks to life and health. *Journal of Economic Literature* 31:1912-46.

predictions. Standard CO-OPS data products are provided at no cost to users primarily over the internet, and in many cases by telephone via toll free numbers. CO-OPS charges a fee for non-standard product support to private organizations – typically the time and media supplies required to assemble the requested data set. CO-OPS fills about 500 formal major data requests from private sector organizations each year, and another 800 "quick responses" (Ehret p.c. 2004). The major requests range from data for a single location (for a local newspaper) to data for all locations (for the Weather Channel).

Product Utilization Data

Water Level and Current Information

The best indication of direct access to and utilization of CO-OPS water level and current information is the utilization of the web page interfaces to this information. Commercial shipping interests and recreational boaters and fishermen, along with members of the general public with an interest in marine conditions (especially during extreme weather events), are thought to account for the majority of the internet access activity, although no systematic survey of CO-OPS web users' purposes has been undertaken to date.

The general CO-OPS web pages field about 4.8 million total visits from about 500,000 unique visitors (users) per year. About 75% of data requests are for historical observations, and 25% are for predictions.

The CO-OPS tides and currents pages (http://tidesandcurrents.noaa.gov/) are the new main interface to CO-OPS water level and current data. They received about 400,000 hits/day in late 2005 and early 2006. Significant spikes in hit rates were recorded during hurricanes Rita (near doubling of the average hit rate) and Katrina (275% increase) in the 2005 hurricane season. Tides Online (http://tidesonline.nos.noaa.gov/), CO-OPS' graphical interface to tide data, recorded an average of 83,000 hits/day during 2005 (30.5 million hits/year).

The PORTS® data interfaces provide information to some 17 million web hits and on the order of 100,000 voice phone calls per year. Table 2 summarizes the daily average web and voice access rate for PORTS® data in 2004.

PORTS® installation	***Average daily web hits***	***Average daily voice calls***
Houston/Galveston	34,400	63.4
New York	2,000	6.4
San Francisco	300	14.6
Tampa Bay	300	80.0
Chesapeake Bay	1,800	39.4
Narragansett Bay	3,000	7.5
Soo Locks	500	40.2
Delaware Bay	1,000	13.4
Anchorage	3,600	4.4
Tides Online (PORTS® stations only)	1,800	---
Total	**46,600**	**269.1**

Table 2: Average daily web page hits and voice data request calls to PORTS installations in 2004. Source: NOAA CO-OPS.

A recent study of Tampa Bay PORTS® data utilization[4] concluded that PORTS® data in Tampa Bay are used by nearly all of the 7,000 annual commercial vessel transits but by only a small fraction of the 110,000 recreational boaters in the area. Tampa PORTS® fields about 100,000 web requests and 30,000 voice data requests per year.

The annual transits for locations covered by the full suite of PORTS® installations is on the order of 100,000 (40,000 for New York/New Jersey, 30,000 for Houston/Galveston, 8,000 for San Francisco Bay). If the findings from Tampa Bay can be generalized to all PORTS installations, this suggests an annual utilization of PORTS® data for about 100,000 commercial ship transits – primarily for the purpose of facilitating safe and efficient passage through the port (avoiding grounding or collisions due to tide/wind), and in a small fraction of cases (perhaps 1%, in the case of Tampa Bay) to assist in maximizing the loaded draft the vessel can safely carry on its transit.

Based on these numbers, the commercial shipping transits appear to account for only a small fraction (order of 1 percent) of the annual instances of access to CO-OPS data. If only 1 percent of marine recreational users get their tide predictions directly from CO-OPS (see below), this would account for some 5 million recreation-days/year with direct access to CO-OPS data – a reasonable number, given 17 million internet visits/year to PORTS® data alone.

Tide Table Books

Printed Tide Tables are carried as a matter of law by all SOLAS vessels operating in US waters. There are about 10,000 such vessels in the world fleet (this is also approximately the annual number of Tide Tables printed today). It seems reasonable to assume that the Tide Tables (or equivalent) are consulted by vessel operators on most of the 500,000 commercial transits that take place in US ports each year.

Weather and Storm Surge Forecasts

The Tampa Bay PORTS® data is estimated to play a role in generating weather and storm surge forecasts affecting some 1 million households. This translates into 20 million potential household-utilizations of storm surge predictions and perhaps 400 million utilizations of general weather forecasts per year in the Tampa Bay area. Scaling these numbers to the national level is precarious because the degree to which local weather forecasts use PORTS® or CO-OPS data may vary from one location to another. A factor of 10 is probably quite conservative in scaling from Tampa Bay to all CO-OPS data, and suggests a lower bound estimate of 200 million storm surge and 4 billion general weather forecast household utilizations of CO-OPS data per year.

General Tide Predictions

Only a small fraction of the routine tide predictions used by recreational boaters and fishers in planning some 500 million person-days of marine boating/fishing per year is likely to come directly from CO-OPS. Many boaters and fishermen rely on tide

[4] Tampa Bay Harbor Safety and Security Committee. 2005. Estimating Economic Benefits from NOAA PORTS® Information: A Case Study of Tampa Bay. Tampa: Tampa Bay Port Authority.

predictions published by local media or specialty publications; and it is not known what fraction of these are derived directly from CO-OPS predictions as opposed to predictions generated by others. It is also not known exactly what fraction of boaters and fishers (and general beach recreationists, for that matter) make use of tide predictions to plan their activities. However, since harmonic constituents derived by CO-OPS remain the standard and officially accepted basis for tide prediction, and since tide level and current is important to much marine boating and fishing, it seems likely that CO-OPS data plays at least an indirect role in some 500 million instances of marine recreational activity per year.

General tide predictions are also likely to be used by some 300,000 commercial fishing vessel transits per year.

Summary and Discussion

Direct and Indirect Use of CO-OPS Data

CO-OPS data may be used either directly (by a user accessing CO-OPS information online or via a data request to CO-OPS) or indirectly (by using a weather forecast or tide prediction, published by an agency other than CO-OPS, that incorporates CO-OPS data). Table 3 summarizes the estimates generated in this report for the annual utilizations, or instances of CO-OPS data reaching end users, per year. The table distinguishes between near-real time (RT) data (often associated with PORTS®), predictions (such as those published in the Tide Tables), and historical records. Indirect utilization of CO-OPS data is indicated by shaded fields in Table 3.

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USCG (SAR) NOAA Hazmat		[30,000] SAR cases [1,000] hazardous material spills		
US Navy, US Coast Guard	[500] vessels	[20,000] transits		
science, environmental management, infrastructure projects	[10,000] marine GIS users	[1,000] ?	[1,000] ?	[1,000] ?
public weather forecasts	[10 million] households	[4 billion] household-days		
storm surge predictions	[10 million] households	[200 million] household-days		

Table 3: Scale of user base and frequency of CO-OPS products reaching end users, 2004. [Brackets] indicate that numbers are approximate, and should in most cases be treated as order of magnitude estimates. Shaded boxes represent indirect utilization of CO-OPS data.

The commercial shipping industry, the US military, and government agencies responsible for search & rescue (SAR), hazardous material spill response and planning, and environmental management, account for between 500,000 and 1 million instances of direct use of CO-OPS data each year. Recreational users may account for another 5 million instances of direct use per year, although the evidence for this is less certain. Instances of indirect use of CO-OPS data are estimated on the order of 1 billion/year for marine applications (tide predictions and storm surge forecasts), or 5 billion/year if general weather forecasts incorporating CO-OPS data are included.

Digital Delivery and Utilization of Data

Because of significant growth in the recreational and coastal resident user base, the traditional users of CO-OPS products – maritime transportation and the US military – account for a small fraction of the total user base today. US Naval ships now number about 300, and the fleet has been shrinking since the mid-1980s. The number of commercial vessels operating in US waters – on the order of 10,000 – has at best grown modestly in the past two decades (though the average vessel has grown in size and cargo capacity terms). By contrast, the number of recreational boats – measured in the hundreds of thousands – has been growing substantially. And the number of users of general weather and storm surge predictions, who are indirect users of CO-OPS data, is larger still.

These changes in the user base numbers are accompanied by changes in the way users access and use CO-OPS data. Although printed tide tables remain in use, primarily on commercial and military ships, they account for a small fraction of total CO-OPS data utilization today. Recreational users are leading the transition to digital navigation tools: electronic chart devices are now commonplace. Military and commercial users are following close behind: the US Navy is moving rapidly toward "paperless" (digital) navigation, and while digital navigation is not yet the norm in commercial maritime shipping, some commercial vessels also carry electronic chart equipment. Weather information in general is increasingly received by the public via online media.

Because of its scale, the recreational user community is likely to account for a significant fraction of the total benefit derived by the nation from CO-OPS activities. Although no formal data are available to support the assertion, it is reasonable to assume that the proper use of tide and current information can contribute to safety and recreational value in recreational boating and fishing. CO-OPS can maximize the value of its data to the recreational boating community by ensuring that interfaces to CO-OPS data are "friendly" to these users.

Promising Areas for Economic Analysis

The findings of this report suggest several areas where the economic value generated by present or potential future CO-OPS activities may be particularly significant, either because of the size of the user base or because of the large unit value associated with events. These may be worth investigating in more detail:

- PORTS® installations (as done recently for Tampa Bay): studies to quantify utilization of and economic benefits from PORTS® data
- utilization of tide predictions by recreational users (large user base): describe and estimate economic value of use of tide predictions by recreational users
- utilization of CO-OPS data in weather and storm surge prediction (large user base): describe and estimate economic value of CO-OPS data in "normal" weather and storm surge forecasts issued by the National Weather Service
- value of improved surface current now- and forecasts to Search & Rescue (SAR) and spill response activities (large unit value): estimate the physical effect and economic value of using CO-OPS data in spill response and in SAR missions

Relation to Improved Ocean Observing System Efforts

Given its experience with the routine operational collection and management of water level, current, and other oceanographic data, CO-OPS seems ideally positioned to play a central role in future efforts to build and operate improved ocean observing systems, particularly in the US coastal zone. In fact, the water level network maintained by CO-OPS and the PORTS® installations CO-OPS manages might be considered a useful starting point for the development of expanded coastal ocean observing activities. Future coastal ocean observing systems are likely to evolve in a decentralized manner, with specifics of their configuration and operations tailored to local and regional user needs – but with a degree of centralized quality control and data management and dissemination. This is the essence of what CO-OPS does today, and probably ought to be its focus going forward.

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